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# Managing Shortleaf Pine in Littleleaf Disease Areas

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COVER PHOTO:

Healthy tree on the right, littleleaf trees at left and center.

# MANAGING SHORTLEAF PINE IN LITTLELEAF DISEASE AREAS[1]

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## INTRODUCTION

Investigations on the cause of the littleleaf disease of shortleaf and loblolly pines, and on possible remedial measures, have been in progress for approximately 12 years. In 1945, the results of investigations up to that time were summarized in a U. S. Department of Agriculture Circular (5). Since then numerous publications have appeared on the cause, soil relationships, and related phases of the study. Recommendations for management of shortleaf pine in areas where the disease is common are summarized here for use by foresters and landowners.

## DISTRIBUTION AND ECONOMIC IMPORTANCE OF LITTLELEAF

Littleleaf occurs in varying amounts in seven southeastern States (fig. 1). The littleleaf belt extending from Virginia to Mississippi embraces approximately 30 million acres, of which over half is in forests. The darker shaded portions of the map, which indicate areas of abundant littleleaf, cover about 5 million acres of forest land.

Even in areas of greatest abundance, littleleaf is not uniformly distributed throughout shortleaf pine stands. Age of stand, soil conditions, and degree of erosion are important factors in the distribution of the disease. In the Piedmont and other physiographic regions where littleleaf occurs, limited areas of severe littleleaf may be found in close proximity to healthy stands. This spotty occurrence of littleleaf in many areas and relative lack of the disease in nearby stands makes an understanding of its cause and soil relationships rather important.

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1/ The littleleaf disease research program has been carried on mainly in cooperation with the Southeastern Forest Experiment Station, U. S. Forest Service, and the School of Forestry of the University of Georgia.

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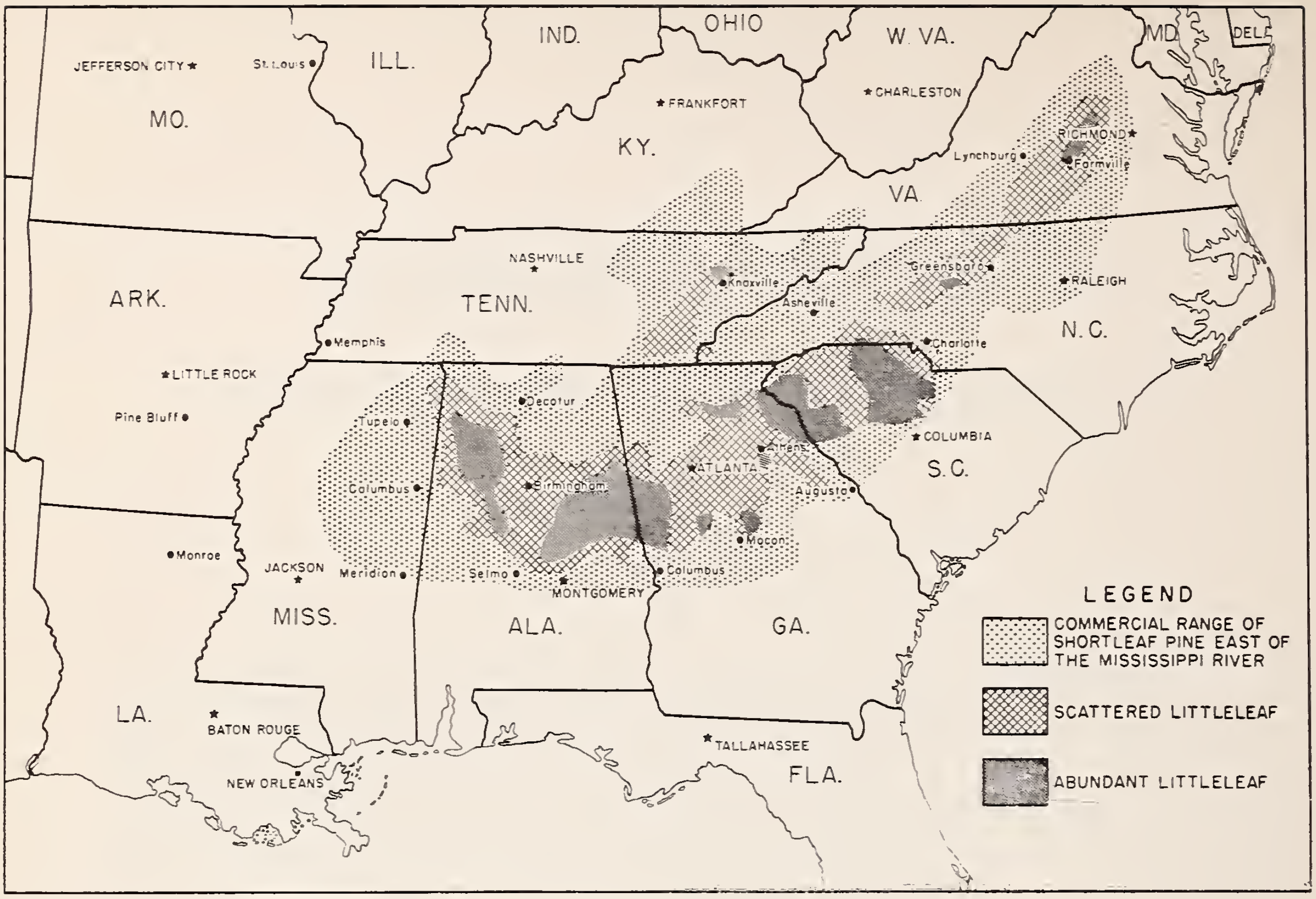



Figure 1.--Known distribution of littleleaf disease of shortleaf and loblolly pines.

No discussion of littleleaf would be complete without some estimate of the losses caused by it on approximately 15 million acres of forest land within the littleleaf belt. Fortunately, valid estimates on the losses from littleleaf in Piedmont South Carolina exist from a forest survey made in 1947 (4). At that time 118 million board feet of shortleaf pine were recently dead or in the advanced stages of the disease. This meant that about 39 million board feet would die each year, since trees in the advanced stages have a life expectancy of less than 3 years. The data for South Carolina were computed independently for areas of scattered and abundant littleleaf, thus making possible estimates of mortality in the other six States. These estimates are given in table 1. Due allowances have been made for differences in forest acreage and other factors such as relative age of stands. Estimates are also included for loblolly pine mortality in States in which an appreciable volume of this species is affected by littleleaf.

Not all expected mortality can be considered as loss, since much salvage cutting of diseased trees prior to death is done in littleleaf-affected areas. Although no allowance for trees salvaged was made in the loss estimates, the salvage is probably more than counterbalanced by loss in increment due to the understocking of littleleaf-ravaged stands, and the growth loss in diseased trees prior to death. As soon as littleleaf symptoms appear, radial growth practically stops, and although diseased trees may live for 10 or more years from the onset of symptoms, they do not increase materially in size. Another type of indirect loss arises from the accelerated conversion of pine stands to hardwoods, which takes place as pines are killed by littleleaf.

Besides the loss in trees of saw-timber size in South Carolina, 46,000 cords of wood in the 6 to 8-inch class are killed annually by littleleaf. This would conservatively place the annual mortality in trees of this size over the entire littleleaf belt at more than 250,000 cords.

Table 1.--Estimated annual mortality from littleleaf, based on 1947 field data

| State | Shortleaf pine | Loblolly pine |
|---|---|---|
| | M bd. ft. | M bd. ft. |
| Alabama | 69,000 | 13,000 |
| Georgia | 55,000 | 5,000 |
| Mississippi | 1,400 | 0 |
| North Carolina | 9,800 | 0 |
| South Carolina | 38,000 | 3,800 |
| Tennessee | 5,000 | 0 |
| Virginia | 15,000 | 0 |
| Total | 193,200 | 21,800 |

## THE CAUSE OF LITTLELEAF

The symptoms of littleleaf develop largely from the gradual killing of the fine roots by the parasitic fungus Phytophthora cinnamomi and probably to a lesser extent from other cuases. Experimental inoculations have demonstrated that new root ends and very young roots are most susceptible to infection. The gradual loss of the fine absorbing roots interferes especially with the absorption of nitrogen, leading to a slow cessation of growth and yellowing of the foliage, followed by premature death.

Phytophthora cinnamomi is widely distributed in the soils of the Southeast, occurring in the coastal plain and other areas where littleleaf is absent. Its ability to attack roots severely depends to a great extent on soil type and condition. Experimental work has shown that root infection is very limited in sandy soils, more common in loams, and severe in silts and clays. Since the fungus requires abundant moisture to produce the swarm spores that cause infection, root damage increases as the subsoils become more poorly drained. The relationship between soil internal drainage and root infection helps to explain why the disease is confined to the heavier soils of the Piedmont and related areas.

Recognition of the role played by a parasitic root fungus and of its dependence upon certain soil conditions to cause severe root mortality is important in the development of plans for the management of littleleaf areas. The disease does not normally spread from diseased trees to healthy trees through transfer of inoculum. The fungus is already present in most southeastern pine soils and the development of littleleaf is conditioned almost entirely by soil factors which cannot be changed materially except over long periods of time.

## SOIL SERIES AND SOIL CONDITIONS IN RELATION TO LITTLELEAF

Early progress reports on the investigation of littleleaf suggested that severe symptoms were associated with frequent burning, low site index, soil erosion, and steep slopes. In 1948, on the Calhoun Experimental Forest near Union, South Carolina, on various soil associations littleleaf severity was found to increase as internal drainage of the soil profiles became poorer (2).

In order to explain these apparent relationships, a more extensive soils-littleleaf study was begun in 1949 throughout the littleleaf region of the southern Piedmont. Forest vegetation, soil characteristics, and disease severity were studied in the search for factors associated with the disease.

The amount of littleleaf varies greatly on different soils, and although disease severity may vary from site to site on any one particular soil, the average amount of littleleaf follows a fairly regular relationship to the internal drainage condition of a particular soil series (table 2). Internal drainage is defined as "that quality of a soil that permits the downward flow of excess water through it" (1). Soil texture, structure, porosity, height of water table and other factors influence it. Thus, soils with poor internal drainage are usually more nearly saturated and reciprocally less well-aerated for long periods of time and this leads to the development of less extensive pine root systems and favors infections by the root fungus *Phytophthora cinnamomi*.

Table 2.--A comparison of littleleaf incidence by Piedmont soil groups according to their internal drainage

| Soil series group | Plots | Littleleaf trees (weighted mean) | Internal drainage |
|---|---|---|---|
| | Number | Percent | |
| Durham, Alamance, Cecil, Georgeville, Davidson, Lockhart, Lloyd, Nason | 66 | 3.9 | Excellent to good |
| Louisa, Madison, Appling, Helena | 39 | 12.1 | Good to poor |
| Cataula, Mecklenburg, Orange, Vance, Tatum, Herndon, Manteo, Wilkes | 53 | 25.5 | Generally poor |

Two shortleaf pine stands, one healthy and the other severely diseased, on two different soils are illustrated in figure 2. The healthy stand is located on a well-developed Cecil sandy loam with medium to rapid internal drainage. At corresponding depths the transmission rates of water (measured as the flow of water through saturated cores) in the Cecil soil range from 10 to 20 times greater than in the shallow, eroded Vance sandy loam with slow internal drainage which supports the diseased stand. Greater porosity in the Cecil profile is apparent and contributes to better drainage.

According to the position of these two soils in table 2, it is apparent that the Cecil soil would normally support healthy or only light littleleaf stands, while moderate

## CECIL *SANDY LOAM*

| DEPTH<br>INCHES | TRANSMISSION RATE<br>INCHES PER HOUR | PORE SPACE<br>PERCENT |
|---|---|---|
| 0 – 2 | 10.90 | 59.7 |
| 2 – 4 | 1.62 | 43.8 |
| 4 – 6 | 0.64 | 36.7 |
| 6 – 8 | 0.79 | 38.6 |
| 8 – 10 | 0.40 | 30.1 |
| 10 – 12 | 0.65 | 26.8 |
| 12 – 14 | 0.34 | 14.1 |
| 14 – 16 | 0.18 | 10.6 |
| 16 – 18 | 0.10 | 5.7 |
| 18 – 20 | 0.15 | 9.1 |
| 20 – 22 | 0.10 | 12.0 |
| 22 – 24 | 0.05 | 11.2 |
| 24 – 26 | 0.10 | 7.7 |
| 26 – 28 | 0.04 | 6.8 |
| 28 – 30 | 0.03 | 6.9 |

30+ DISINTEGRATED ROCK

## VANCE *SANDY LOAM*

| DEPTH<br>INCHES | TRANSMISSION RATE<br>INCHES PER HOUR | PORE SPACE<br>PERCENT |
|---|---|---|
| 0 – 2 | 0.94 | 33.2 |
| 2 – 4 | 0.10 | 12.2 |
| 4 – 6 | 0.03 | 9.9 |
| 6 – 8 | 0.05 | 7.4 |
| 8 – 10 | 0.02 | 8.1 |
| 10 – 12 | 0.01 | 8.9 |
| 12 – 14 | 0.01 | 6.6 |
| 14 – 16 | 0.01 | 9.7 |

16+ DISINTEGRATED ROCK

Figure 2.--A healthy shortleaf pine stand on a Cecil sandy loam on left; a stand with littleleaf on a Vance sandy loam on right.

to severe littleleaf may be expected in stands occurring on the Vance soil. Thus table 2 affords a means of approximating expected littleleaf severity on different soil series.

More than thirty soil, vegetation, or fungus factors have been studied in relationship to littleleaf. Only two soil features, internal drainage and degree of soil erosion, are statistically significantly correlated with littleleaf severity. These two factors provide the basis for the development of a guide for estimating the littleleaf hazard for any site.

## PREDICTING THE LITTLELEAF HAZARD FOR DIFFERENT SITES

An urgent need exists for a practical field guide for predicting the littleleaf hazard on different sites throughout the littleleaf region. Such a guide must necessarily be usable by foresters in the field without requiring detailed laboratory analyses or measurements.

Since a significant relationship exists between groups of soils and littleleaf severity, soil units such as series or types might be used as a guide in determining the probable disease hazard (see table 2) provided proper classification of the soil unit is made. However, in old agricultural areas, this method of estimating disease hazard could only, at best, result in predictions of a general nature because diverse farming practices have produced alterations in the original soils which may not be reflected by the mere classification of the soil as to its proper series. Therefore, a more precise rating guide is needed.

A simplified rating scale, of a preliminary nature, developed from field notes of an extensive soils-littleleaf survey is presented in figure 3, and is based upon two soil characteristics, internal drainage and soil erosion. The degree of soil erosion can be classified fairly readily; however, the accurate classification of internal drainage is difficult and requires considerable training and experience. Therefore, erosion is used in the rating scale, but three more easily evaluated characteristics--subsoil consistence, depth to zone of greatly reduced permeability, and subsoil mottling--are substituted for internal drainage. These three substituted characteristics adequately characterize internal drainage for the purpose of this rating scale.

A site expected to remain disease-free is assigned a total of 100 points. This is broken down so that 40 points are allocated to the erosion factor and 60 points to the internal drainage factor. The further division of the 60 points between the three soil characteristics used in lieu of internal drainage is shown in figure 3. It is necessary to understand the terms used in the rating scale before any attempt is made to use it.

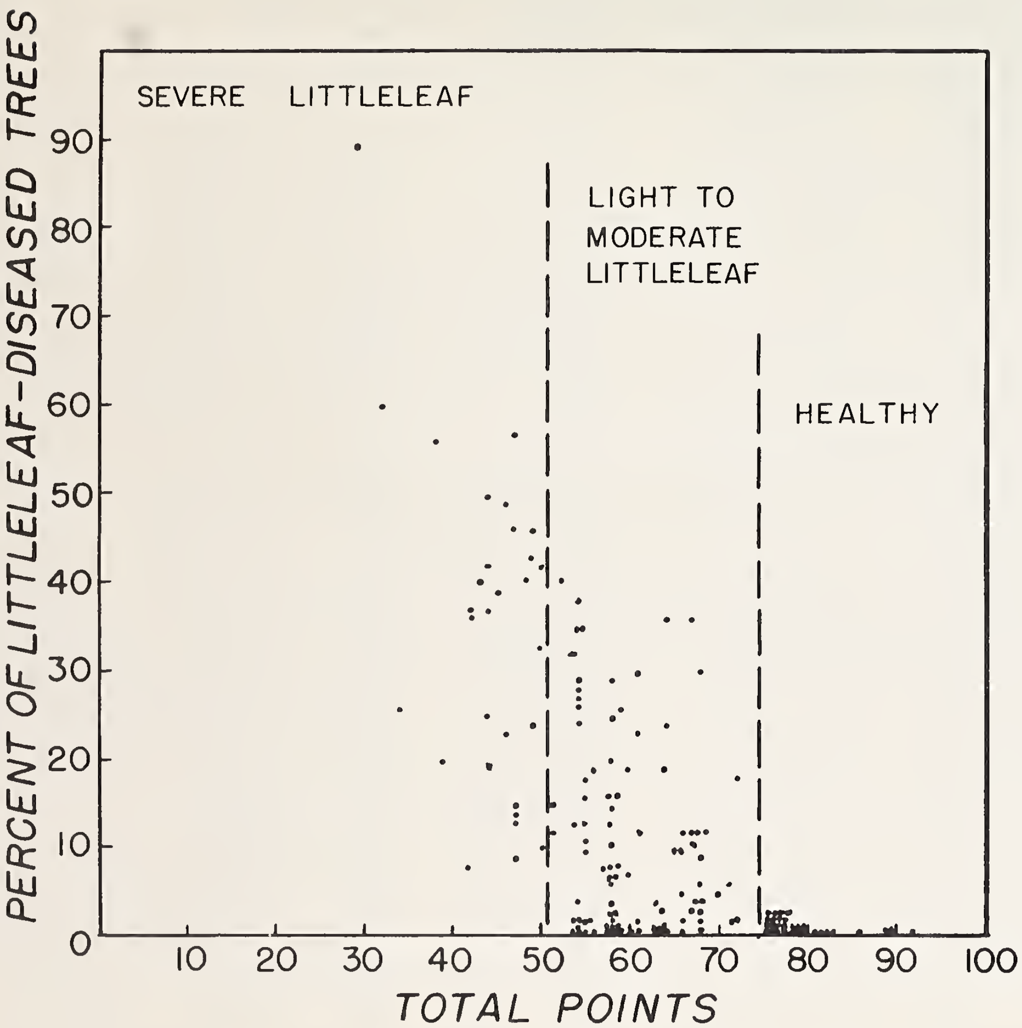
The term erosion as used in this discussion denotes accelerated water erosion and the classes used are essentially those recognized by the U. S. Division of Soil Survey (1).

Slight erosion.--The thickness and character of the A horizon has not been altered to an appreciable extent. Not more than 25 percent of the original A horizon has been removed.

Moderate erosion.--The soil has been eroded to the extent that ordinary tillage implements reach through the remaining A horizon. From 25 to 75 percent of the original A horizon may have been lost. Shallow gullies may be present.

Severe erosion.--All or practically all of the original A, and commonly part of the B, horizon have been lost. Shallow gullies are common.

Rough gullied land.--The land presents an intricate pattern of moderately deep or deep gullies. Soil profiles have been destroyed except in small areas between gullies.




| SOIL CHARACTERISTICS AND CLASS | POINTS |
|---|---|
| **EROSION** | |
| Slight | 40 |
| Moderate | 30 |
| Severe | 20 |
| Rough gullied | 10 |
| **SUBSOIL CONSISTENCE** | |
| Very friable | 32 |
| Friable | 24 |
| Firm (slightly plastic when wet) | 16 |
| Very firm (plastic when wet) | 8 |
| Extremely firm (very plastic when wet) | 0 |
| **DEPTH TO ZONE OF GREATLY REDUCED PERMEABILITY** | |
| 24 - 36" | 15 |
| 18 - 23" | 12 |
| 12 - 17" | 9 |
| 6 - 11" | 6 |
| 0 - 6" | 3 |
| **SUBSOIL MOTTLING** | |
| None | 13 |
| Slight | 9 |
| Moderate | 5 |
| Strong | 1 |

Figure 3.--A soil rating scale for estimating the littleleaf hazard of a site, in which the higher the index the lower the littleleaf hazard. By the use of four soil factors, the 158 plots in the South Carolina survey are classified in the scatter diagram.

Soil consistence is that quality of soil material which is expressed by resistance to deformation. As used in this discussion, subsoil consistence is determined when the moisture content of the subsoil is approximately midway between air dry and field capacity. To evaluate consistence, select and attempt to crush in the hand a mass of soil that feels slightly moist. Customarily, descriptions of consistence refer to that of soil from undisturbed horizons. Five recognized consistence classes for moist soil are used in the littleleaf prediction rating scale (1). They are defined below.

Very friable.--Soil material crushes under very gentle pressure but coheres when pressed together.

Friable.--Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.

Firm.--Soil material crushes under moderate pressure between thumb and forefinger but resistance to pressure is distinctly noticeable. Slightly plastic when wet.

Very firm.--Soil material crushes under strong pressure; barely crushable between thumb and forefinger. Plastic when wet.

Extremely firm.--Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit. Very plastic when wet.

The depth to the zone of greatly reduced permeability is determined from soil pits dug by the observer and the accuracy of this determination depends upon his judgment and experience. Certain conditions such as denseness of soil layers, resistance encountered in digging, texture of soil layers, absence of cracks and large pores, and others, aid in locating this zone of reduced permeability. Usually this zone occurs near the top of or within the B horizon (1 to 3 feet), and when it is located the observer simply measures the depth to it from the soil surface.

Mottling in a soil is a splotching of a uniform color with spots of other colors. It is described by the prominence, abundance, and size of individual mottles. Within the littleleaf region, the mottling, mainly grays and browns, in soil is evidence of water saturation. It indicates impeded drainage and is usually restricted to the subsoil. Four relative classes of mottling are included in the rating scale. No great difficulty should be experienced in evaluating this factor according to the classes listed.

There are several tools available for use in examining soils--the conventional soil auger, the post-hole auger which is larger, a spade, mattock, and the common post-hole digger. The common post-hole digger is preferred because it does not grind, pulverize, or mix the soil as much as the augers. This is especially desirable for determining consistence and mottling.

As a test of its usefulness, the rating scale was applied to the 158 plots of the South Carolina soils-littleleaf survey. The plots fall into three classes: healthy sites having a rating of 75 or more points; light to moderate littleleaf hazard sites having 51 to 74 points inclusive, and severe littleleaf hazard sites having less than 51 points. The classification of the survey plots by the use of the rating scale plotted against the actual percent of littleleaf trees is shown in the scatter diagram of figure 3. The results compare favorably with the actual field classification. The healthy plots that occur in the light to moderate littleleaf group in the rating scale average 8 years younger than the healthy group and probably represent stands approaching the threshold of disease expression.

The mechanics of rating sites can be illustrated by rating the two sites in figure 2. The Cecil soil is slightly eroded, subsoil consistence is friable, depth to zone of greatly reduced permeability is 16 inches, and the subsoil is free of mottling. The Vance soil is severely eroded, subsoil consistence is very firm, depth to

zone of greatly reduced permeability is 4 inches, and the subsoil is moderately mottled. Referring to the rating scale (fig. 3), the Cecil soil has a rating of 86 points, which places it in the healthy group. The Vance soil has a rating of 36 points, which places it in the severe littleleaf group. The photographs corroborate these ratings.

## SUGGESTED MANAGEMENT PRACTICES IN RESPECT TO STAND AND SITE CONDITIONS

An analysis of the shortleaf pine stands within the littleleaf belt and associated potential pine sites discloses four situations, each requiring a different approach to the management problem. These are discussed as follows:

### Stands in which Littleleaf is Present

Although littleleaf may develop in stands as young as 20 years of age, the majority of those becoming diseased show first symptoms between 30 and 50 years of age. In general, the earlier symptoms appear, the more severe the resulting effect on the stand. Obviously, greater loss will result in those stands showing disease at an early age, because most of the diseased trees that should be salvaged will be too small to market except as pulpwood. Stands becoming diseased at a later date often produce a considerable volume of saw timber.

The first problem in dealing with littleleaf stands is that of properly spacing cuttings to minimize the loss of merchantable timber. Suggested cutting cycles are based on the amount of disease in the stand and the known rate of deterioration of affected trees. Elmer Roth, in a study now in progress, has analyzed the data on the dominant and codominant trees from 31 permanent sample plots covering the 10 years between 1941 and 1951. On the light littleleaf plots, in addition to the mortality among the scattered littleleaf trees that were present when the plots were established in 1941, 34 percent of the originally healthy trees showed symptoms in 1951 and 4 percent had died. On the moderate littleleaf plots, in addition to the mortality among trees originally diseased in 1941, 51 percent of the healthy trees had developed symptoms by 1951 and 8 percent had died. On the severe littleleaf areas 67 percent of the healthy trees became diseased in 10 years and 27 percent died. Therefore, on severe littleleaf areas, the expected mortality among healthy trees plus the loss of trees already diseased would lead to serious stand depletion over a relatively short period.

Hepting (3) formulated the following cutting rules for lightly, moderately, and severely diseased stands, assuming that the stands in question are relatively accessible and that littleleaf trees live for an average of 7 years from the onset of symptoms and those in advanced stages less than 3 years:

(1) Where only an occasional shortleaf pine shows littleleaf, cuts can be light and spaced at least 10 years apart.

(2) When between 10 and 25 percent of the trees show unmistakable littleleaf, cut on at least a 7-year cutting cycle, cutting all diseased or suspected trees at each cut.

(3) Where more than 25 percent of the trees show littleleaf, cut all shortleaf pine as soon as practicable from the standpoint of merchantability, since such stands are likely to deteriorate very rapidly once one-fourth of the trees are obviously diseased.

With the harvesting of present littleleaf stands, the question arises as to future prospects for shortleaf pine on the same sites. Because the disease is associated with soil conditions that cannot be greatly changed except over long periods of time, succeeding crops of shortleaf pine may be expected to fail at the same or even at an earlier age. However, since many of these sites provide satisfactory yields of pulpwood, they may be managed on short rotations without undue interference from this disease.

Soil improvement has been suggested as one means of combating littleleaf. This can be accomplished by encouraging hardwoods, especially such species as dogwood, yellow-poplar, and hickory, which are known to improve soils. Hardwoods are more effective than pine in building humus. Metz (7) lists the common Piedmont hardwoods by their yield of nitrogen, calcium, and magnesium from the foliage. Practically all hardwoods return more nitrogen, calcium, and other elements to the soil than pine, and the eventual change to a greater proportion of broad-leaved species in littleleaf areas may serve to reduce the incidence of disease, not only by decreasing the number of trees that are susceptible to attack, but also by providing more favorable growth conditions for the existing pine. However, any effect on pine would be on future stands, and those older individuals now occupying the site could scarcely be expected to benefit immediately by conversion to hardwoods.

Loblolly pine on severe littleleaf sites is approximately one-third as susceptible as shortleaf and should, therefore, be favored wherever possible. Also, other pines, such as Virginia, pitch or longleaf should be encouraged, where feasible, in order to build up the percentage of resistant or immune species in future stands.

Littleleaf will continue to present a hazard to shortleaf pine production on sites where it now occurs. After cutting has been adjusted to prevent loss of the present crop, little can be done to insure successive crops of pine free from disease. Except on the worst littleleaf sites, shortleaf and loblolly can be managed as a short rotation crop, the disease hazard predictable from the performance of the present stands.

## Older Stands that Have Remained Healthy

Within the littleleaf belt there are numerous stands that have remained healthy up to 40 or 50 years of age or were healthy at the time of harvest. Such sites present little hazard from littleleaf and can be managed on the basis of normal shortleaf stands outside the littleleaf belt.

Succeeding generations of pine on these sites should be free from littleleaf because soil conditions that predispose the species to attack probably are unfavorable for damaging activity of the root parasite.

## Healthy Stands up to 40 Years of Age

The delayed onset of littleleaf in many stands and its increased prevalence in the 30 to 50-year age classes make it difficult to predict the future of young stands in respect to the disease. However, the soil and site studies already described offer a means of measuring the relative hazard for different stand conditions. Another indicator of the disease hazard is the growth response of individual trees. Stands in which littleleaf may eventually develop usually show an uneven growth response of individual trees as the threshold of age for symptom expression is approached. Any stand not yet showing littleleaf symptoms should be considered suspicious if bushy, stunted, yellowish-green trees develop among the more normal individuals. This unevenness of growth between dominant and codominant trees is probably the result of root injury that eventually leads to littleleaf.

Examination of soil conditions under young stands offers a means of predicting the potential littleleaf hazard. Sites rating over 75 on the littleleaf hazard rating scale should remain relatively free of littleleaf indefinitely. Those rating from 50 to 75 may develop light to moderate littleleaf after they are 30 years of age. Stands originating on badly eroded sites having heavy exposed subsoil must be considered poor risks from littleleaf at an early age.

After the littleleaf hazard for a given stand has been determined, management plans can be more accurately charted. Under such plans littleleaf sites would be used largely for short-rotation products such as pulpwood.